

## 桑白皮中抗人爱滋病病毒(HIV)成分研究

罗士德<sup>1</sup> J. Nemec<sup>2</sup> 宁冰梅<sup>1</sup>

(<sup>1</sup> 中国科学院昆明植物研究所, 昆明 650204)

(<sup>2</sup> 美国国立癌症研究所)

**摘要** 从中药桑白皮(*Morus alba* L.)的根皮中分离到 6 个成分, 它们是: morusin (1), mulberrofuran D (2), kuwanon H (3), mulberrofuran K (4), kuwanon G (5), mulberrofuran G (6); 并制备了它们的乙酰化合物和葡萄糖甙; 还测定了这些化合物的体外抗人爱滋病病毒(HIV)活性和对人淋巴细胞的细胞毒活性, 发现其中黄酮 morusin, kuwanon H 和 morusin 4'-glucoside 具有一定的抗 HIV 活性。

**关键词** 桑白皮, 黄酮, 抗人爱滋病病毒

## ANTI-HIV FLAVONOIDS FROM MORUS ALBA

LUO Shi-De<sup>1</sup>, J. Nemec<sup>2</sup>, NING Bing-Mei<sup>1</sup>

(<sup>1</sup> Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650204)

(<sup>2</sup> National Institute of Cancer, Frederick Cancer Research Development Center, U.S.A.)

**Abstract** Six compounds: morusin (1), mulberrofuran D (2), kuwanon H (3), mulberrofuran K (4), kuwanon G (5), mulberrofuran G (6) were isolated from root bark of *Morus alba* and their derivatives were prepared. Anti-HIV activity of these fourteen compounds were tested. Morusin, morusin 4'-glucoside and kuwanon H show positive activity.

**Key words** *Morus alba*, Flavonoids, Anti-HIV

San Baipei, root bark of *Morus alba* L. (Moraceae) is a traditional Chinese medicine used as a medication for cough, asthma and other diseases<sup>[1]</sup>. The ethanol extract of San Baipei, which displayed activity against HIV *in vitro* in root of *Morus alba* L. was studied.

Having been extracted with MeOH-CH<sub>2</sub>Cl<sub>2</sub>(1 : 1), the powder of San Baipei was extracted with H<sub>2</sub>O. The biological assay results of both extracts showed that MeOH-CH<sub>2</sub>Cl<sub>2</sub>(1 : 1) extracts are active. CH<sub>2</sub>Cl<sub>2</sub>-MeOH(1 : 1) extracts was partitioned between MeOH-H<sub>2</sub>O (9 : 1) and hexane. Anti-HIV test *in vitro* indicated that MeOH-H<sub>2</sub>O(9 : 1) part have positive activity.

Silica gel column chromatography of MeOH-H<sub>2</sub>O parts gave ten fractions, in which Fr. 3, Fr. 5 and Fr. 6 have anti-HIV activity. Preparative TLC on silica gel of the three active fractions provided two active flavonoids: morusin, kuwanon H and two unactive compounds: mulberrofuran D, mulberrofuran K. Another two inactive compounds: mulberrofuran G, kuwanon G were separated from another two fraction: Fr. 7 and Fr. 9 respectively with the same techniques.

Structures of the six compounds were identified according to their NMR data and other physical and chemical data. Four derivatives of morusin: morusin diacetate, morusin hydroperoxide, morusin 2'-glucoside, morusin 4'-glucoside; three derivatives of kuwanon H: kuwanon H hexacetate, kuwanon H heptoacetate, kuwanon H octoacetate were prepared. The results of anti-HIV tests of these nine compounds indicated that only morusin and morusin 4'-glucoside reserved the activity (Table 1). Taro Nomura and his coworkers reported in 1977 that in molecular of morusin, the site between 2'-free hydroxy and 3-r,r-dimethylallylic group was sensitive to photo-oxidation<sup>[4]</sup>. Therefore we come to the conclusion that 2'-free hydroxy and 3-r,r-dimethylallylic group contributed to the anti-HIV activity of morusin.

This paper is the first report on preparing, physical data, anti-HIV activity and cytotoxicity of morusin 2'-glucoside, morusin-4'-glucoside, kuwanon H hexacetate, kuwanon H heptoacetate, kuwanon H octoacetate and mulberrofurin D triacetate.

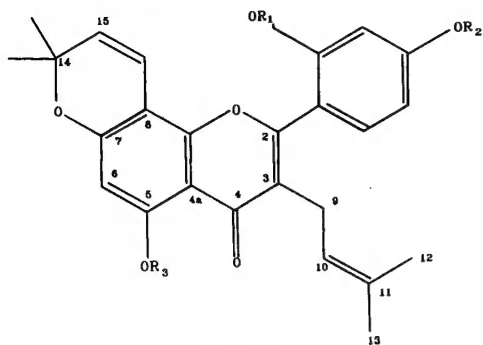
Table 1 Anti-HIV activity (EC50) and cytotoxicity (IC50) of compounds 1 to 14

Compounds	EC50( $\mu\text{g} / \text{mL}$ )	IC50( $\mu\text{g} / \text{mL}$ )
crud extract <sup>1</sup>	1.01E+01	4.52E+01
morusin (1)	2.91E+00	8.18E+00
morusin diacetate (7)		4.43E+00
morusin hydroperoxide (8)		2.13E+01
morusin 2'-glucoside (9)		9.42E+01
morusin 4'-glucoside (10)	7.47E+00	2.29E+01
kuwanon H (3)	1.95E+00	1.34E+01
kuwanon H hexacetate (11)		9.62E+00
kuwanon H heptoacetate (12)		<1.95E+00
kuwanon H octoacetate (13)		<1.95E+00
mulberrofurin D (2)		1.04E+01
mulberrofurin D triacetate (14)		1.65E+01
mulberrofurin K (4)		2.79E+01
mulberrofurin G (6)		2.75E+00
Kuwanon G (5)		4.79E+01

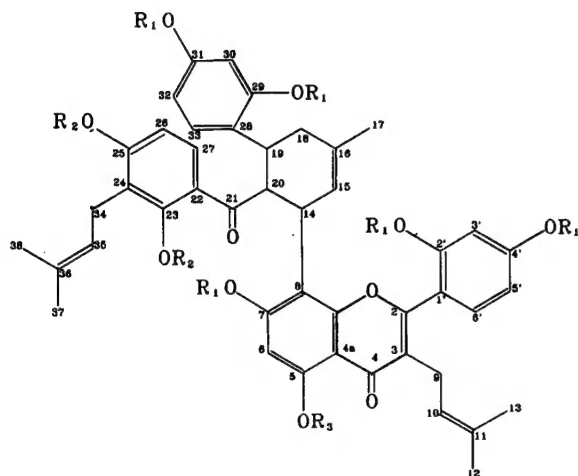
Table 2 Activity of fractions flash chromatography of residue M

Solvents	volume (mL)	Fraction	Yield (g)	Activity	EC50( $\mu\text{g} / \text{mL}$ )
CH <sub>2</sub> Cl <sub>2</sub>	2000	Fr. 1	3.87	-	
+1% MeOH	1000	Fr. 2	0.83	-	
+3% MeOH	1000	Fr. 3	2.06	++	4.88E+00
+3% MeOH	1000	Fr. 4	1.03	-	
+6% MeOH	1000	Fr. 5	2.47	++	1.96E+01
+6% MeOH	1000	Fr. 6	1.05	++	2.23E+00
+6% MeOH	1000	Fr. 7	0.43	+	2.24E+01
+10% MeOH	1000	Fr. 8	1.50	-	
+10% MeOH	1000	Fr. 9	0.58	+	3.90E+01
+50% MeOH	1000	Fr. 10	5.72	-	

## EXPERIMENT



Morusin (1):  $R_1 = R_2 = R_3 = H$   
 Morusin-diacetate (7):  $R_1 = R_2 = Ac$   $R_3 = H$   
 Morusin-2'-glucoside (9):  $R_1 = glucose$   $R_2 = R_3 = H$   
 Morusin-4'-glucoside(10):  $R_1 = R_3 = H$   $R_2 = glucose$



Kuwanon H (3):  $R_1 = R_2 = R_3 = H$   
 Kuwanon H hex-acetate (11):  $R_1 = Ac$ ,  $R_2 = R_3 = H$   
 Kuwanon H hepoacetate (12):  $R_1 = R_2 = Ac$ ,  $R_3 = H$   
 Kuwanon H octo-acetate (13):  $R_1 = R_2 = R_3 = Ac$

compounds: morusin and mulberrofuran D were provided.

Morusin (1):  $C_{25}H_{24}O_6$  ( $M^+$  420, 1722) yellow crystal. mp. 168—169°C ( $CH_2Cl_2$ -hexane). MS  $m/e$  (%): 420(55), 405(100), 387(9), 377(23), 203(35),  $IR_{\nu_{max}}^{KBr} cm^{-1}$ : 3400, 2950, 1650, 1560, 1480, 1345, 1150, 975, 840.  $^1H$  NMR( $\delta$ ,  $CDCl_3$ ): 6.21(1H, d,  $J = 0.7$ , H-6), 3.13(2H, dd,  $J = 1.0$ , 6.8, H-9), 5.14(1H, td,  $J = 6.9$ , 1.4, H-10), 1.61(3H, q,  $J = 1.3$ , H-12), 1.45(3H, dq,  $J = 1.0$ , 0.4, H-13), 6.63(1H, dd,  $J = 10.0$ , 0.7, H-14), 5.47(1H, d,  $J = 10.0$ , H-15), 1.44(3H, s, H-17), 1.44(3H, s, H-18), 6.65(1H, d,  $J = 2.2$ , H-3'), 6.45(1H, dd,  $J = 2.3$ , 8.4, H-5'), 7.11(1H, d,  $J = 8.4$ , H-6'),  $^{13}C$  NMR ( $\delta$ , DMSO): 161.3(C-2), 120.7(C-3), 182.5(C-4), 104.9(C-4a), 161.5(C-5), 99.1(C-6), 158.8(C-7), 100.8(C-8), 152.3(C-8a), 24.1(C-9), 121.5(C-10),

Mps.: uncorr.; IR spectra were obtained on a Perkin-Elmer 1430 ratio recording. NMR spectra were determined on a Varian VXR 500s soetrometer and chemical shift values are given in ( $\delta$ , ppm) with TMS as internal standard. MS were obtained using BG Micrimass ZAB-2F instrument. Silica gel 60 (Merck mesh 230-400) was used for CC. and DC-plastic plates (Merck 60 F254) were employed for TLC. Detection of components was performed by spraying with 15%  $H_2SO_4$  solution in ethanol followed by heating or by used of a UV lamp ( $\lambda = 254$ ). The plant materials was purchased from traditional pharmacy in Yunnan province, China in autumn 1989.

Milled plant materials (2kg) was soaked with  $CH_2Cl_2$ -MeOH(1 : 1) for 24h at room temperature. The solution was evaporated in vacul under 40°C, and semi-solid residue M was supplied.

Flash chromatography of residue M (22.8 g) on a column of silica gel 6.5 × 9.2 mm(141.5 g) eluated with solvent system in Table 2 and ten fractions was obtained. The five fractions that showed positive activity were subjected on chromatography respectively.

**Fraction 3:** Fraction 3 was isolated on a chromatotron of silica gel plates (thin layer 4 mm and 1 mm respectively) using solvent system 1%—7 % ethanol and  $CH_2Cl_2$ , two pure

131.9(C-11), 25.5(C-12), 17.4(C-13), 115.1(C-14), 126.3(C-15), 77.6(C-16), 22.7(C-17), 27.7(C-18), 111.6(C-1'), 156.2(C-2'), 103.3(C-3'), 160.3(C-4'), 107.3(C-5'), 131.1(C-6').

**Morusin Diacetate:** Morusin (4 mg) was dissolved in 150  $\mu\text{L}$  of  $\text{Ac}_2\text{O}$  and pyridine (1 : 1) and kepted in the room temperature for 5 minutes. The solution was evaporated in vacuo (0.1 mmHg) for 1.5 min., then 200  $\mu\text{L}$   $\text{CH}_2\text{Cl}_2$  was added in and evaporated for two times. Product was crystallized in Hexane and  $\text{CH}_2\text{Cl}_2$  (5 drops+200  $\mu\text{L}$ ), colorless crystals was obtained.  $\text{C}_{29}\text{H}_{28}\text{O}_3$  ( $M^+$  504.1772) mp. 137.5—138.5 $^\circ\text{C}$ , MS  $m/e$  (%): 504(34), 489(100), 461(10), 419(6), 405(3), 377(6), 203(40),  $^1\text{H}$  NMR ( $\delta$ , DMSO): 6.25(1H, s, H-6), 3.00(2H, br, H-9), 5.03(1H, m, H-10), 1.57(6H, s, H-12,13), 6.45(1H, d, H-14), 5.72(1H, d, H-15), 1.42(6H, s, H-17,18), 7.25(1H, s, H-3'), 7.25(1H, d, H-5'), 7.70(1H, s, H-6'), 2.11, 2.32(2  $\times$  3H, s, Me-CO), 12.9(1H, brs, 5-OH),  $^{13}\text{C}$  NMR ( $\delta$ , DMSO): 158.5(C-2), 119.5(C-3), 181.4(C-4), 104.3(C-4a), 160.9(C-5), 99.3(C-6), 158.4(C-7), 100.5(C-8), 151.5(C-8a), 23.3(C-9), 120.7(C-10), 131.3(C-11), 25.3(C-12), 17.3(C-13), 113.6(C-14), 128.1(C-15), 78.2(C-16), 27.6(C-17), 27.6(C-18), 122.5(C-1'), 148.7(C-2'), 120.6(C-3'), 152.5(C-4'), 117.7(C-5'), 168.6(C=O), 168.6(C=O), 20.8(Me), 20.4(Me)  $^{[3]}$ .

**Morusin 4'-glucoside and 2'-glucoside:** morusin (210 mg) was dissolved in  $\text{CH}_2\text{Cl}_2$  (15 mL), and 1-Br- $\beta$ -D-pyran tetracetate glucose (1.4g) and  $\text{Ag}_2\text{CO}_3$  (1.1g) was added in. The mixture was stirred in nitrogen for 2 h, the more Br-carbohydrate (0.5g) and  $\text{Ag}_2\text{CO}_3$  (0.5g) was put in, stirred for another 3h. filtered, evaporated in vacuo and dissolved in the methanol (5 mL),  $\text{NaOCH}_3$  (5 mL) was added and stirred for 20 min. again, put in carbondioxide gas till the pH value of the solution to 8 or 9, evaporation of solvent gave a residue. The residue is very unstability and easily reduced to morusin on silica gel or in acid it was isolated as soon as possible on chromatography using chromatotron (4 mm and 1 mm thin layer silica gel plate) and solvent system ( $\text{CH}_2\text{Cl}_2$ -Me-OH, 5%—15%), two compounds: 10 (16.7 mg) and 9 (21.5 mg) were gained. 10 and 9 have the same molecular weight, formular and the same no-hydrogen band free hydroxy. But the chemical shift of 3',5' proton of 10 was 3 ppm downfield that of 3' proton of 9 was 0.26 ppm downfield, but 5' proton was only 0.1 ppm downfield, so the 4'-position of 10 was substituted by glucose, and 9 is 2'-glucoside.

**Morusin 4'-glucoside:**  $\text{C}_{31}\text{H}_{34}\text{O}_{11}$ , yellow powder, mp 125—131 $^\circ\text{C}$ .  $\text{IR}_{\text{max}}^{\text{KBr}} \text{cm}^{-1}$ : 3350, 2912, 1705, 1655, 1580, 1485, 1435, 1355, 1155, 1075, 840, 770. MS  $m/e$  (%): 582(100), 567(13), 421(35), 405(25), 365(35), 309(55), 247(36), 219(20), 203(29).  $^1\text{H}$  NMR ( $\delta$ ,  $\text{CDCl}_3$ ): 9.15(1H, brs, OH), 7.33(1H, d,  $J$  = 8.5, H-6'), 6.60(1H, d,  $J$  = 10.0, H-16), 6.88(1H, s, H-3'), 6.78(1H, d,  $J$  = 8.5, 2.3, H-5'), 6.19(1H, s, H-6), 5.68(1H, d,  $J$  = 10.0, H-17), 5.12(1H, m, H-12), 3.10(2H, m, H-11), 1.58(3H, s, H-14), 1.45(6H, s, H-15,19), 1.30(3H, s, H-20), 5.02(1H, d,  $J$  = 7.64, H-1''), 4.10, 3.92, 3.72, 3.55(4  $\times$  H, glucoside H-2'', 3'', 4'', 5''), 3.50(2H, m, H-6'').

**Morusin 2'-glucoside:**  $\text{C}_{31}\text{H}_{34}\text{O}_{11}$ , yellow powder, mp 150—155 $^\circ\text{C}$ .  $\text{IR}_{\text{max}}^{\text{KBr}} \text{cm}^{-1}$ : 3350, 2910, 1700, 1660, 1485, 1405, 1360, 1230, 1160, 1080, 850, 610. MS  $m/e$  (%): 582(15), 421(50), 405(10), 365(12), 309(14), 233(36), 155(97), 135(57), 119(10).  $^1\text{H}$  NMR ( $\delta$ ,  $\text{CDCl}_3$ ): 8.75(1H, brs, OH), 7.25(1H, d, H-6'), 6.67(1H, d, H-16), 6.82(1H, d, H-6'), 6.58(1H, s, H-6), 5.76(1H, d, H-17), 5.14(1H, m, H-12), 3.10(2H, m, H-11), 1.58(3H, s, H-14), 1.45(3H, s, H-15), 1.44(3H, s, H-19), 1.32(3H, s, H-20), 4.78(1H, d, H-1'), 4.10, 3.97, 3.79, 3.57(4  $\times$  H, H-2'', 3'', 4'', 5''), 3.53(2H, m, H-6'').

**Morusin Hydroperoxide:** morusin 10 mg was dissolved in  $\text{CHCl}_3$  and exposed to bright sunshine for 14h, one major spot on the of this solution showed the yield of this component is about 70%, preparing TLC of this solution gave 3 mg yellow needles (MeOH), mp 203—205 $^\circ\text{C}$  is accord with data in

reference<sup>[4]</sup>.

Mulberrofuran D:  $C_{29}H_{34}O_4$  ( $M^+$ 446.2457), mp 121—123°C, colorless crystal.  $IR_{\max}^{KBr} cm^{-1}$ : 3320, 2920, 1615, 1445, 1420, 1310, 1140, 820. MS  $m/e$  (%): 446(100), 377(3), 361(8), 323(11), 307(13), 279(24), 269(8), 188(20), 123(6), 69(15).  $^1H$  NMR ( $\delta$ ,  $CDCl_3$ ): 6.69(1H, s, H-3), 7.28(1H, d,  $J=8.3$ , H-4), 6.78(1H, d,  $J=8.3$ , H-5), 6.42(1H, d,  $J=2.6$ , H-4'), 6.77(1H, d,  $J=2.6$ , H-6'), 3.52(2H, d,  $J=6.6$ , 1.3, H-1''), 5.29(1H, qt,  $J=6.6, 1.4$ ), 1.78(3H, q,  $J=1.1$ , H-4''), 1.76(3H, q,  $J=1.4$ , H-5''), 3.68(2H, dd,  $J=8, 7$ , H-1'), 5.40(1H, q,  $J=1.3, 7.2$ , H-2''), 1.65(3H, t, d,  $J=0.8, 1.4$ , H-4''), 1.76(3H, q,  $J=1.4$ , H-5''), 3.68(2H, dd,  $J=0.8, 7$ , H-1''), 5.40(1H, qt,  $J=1.3, 7.2$ , H-2''), 1.84(3H, td,  $J=0.8, 1.4$ , H-4''), 2.07(2H, m, H-5''), 2.10(2H m, H-6''), 5.05(1H, m, H-7''), 1.65(3H, qd,  $J=0.3, 1.3$ , H-9''), 1.57(3H, qd,  $J=0.6, 1.4$ , H-10''), 5.38, 5.34, 4.92(each 1H brs, OH).  $^{13}C$  NMR ( $\delta$ ,  $CDCl_3$ ): 152.3(C-2), 105.6(C-3), 110.3(C-3a), 118.6(C-4), 112.8(C-5), 154.2(C-6), 132.2(C-7), 152.3(C-7a), 122.1(C-1'), 117.7(C-2'), 156.2(C-3'), 103.7(C-4'), 154.5(C-5'), 108.3(C-6'), 26.4(C-1''), 122.4(C-2''), 134.7(C-3''), 17.9(C-4''), 25.6(C-5''), 23.1(C-1''), 120.9(C-2''), 139.1(C-3''), 16.2(C-4''), 39.6(C-5''), 26.3(C-6''), 123.7(C-7''), 132.0(C-8''), 25.7(C-9''), 17.6(C-10'')<sup>[5]</sup>.

Mulberrofuran D Triacetate:  $C_{35}H_{40}O_7$ , mp 97—98°C,  $IR_{\max}^{KBr} cm^{-1}$ : 2920, 1770, 1750, 1610, 1485, 1370, 1200, 1135, 1025, 920, 830, 685,  $^1H$  NMR( $\delta$ ,  $CDCl_3$ ): 6.84(1H, s, H-3), 7.42(1H, d,  $J=8.2$ , H-5), 7.35(1H, d,  $J=2.4$ , H-2'), 6.95(1H, d,  $J=2.4$ , H-4'), 3.47(2H, t,  $J=6.2$ , H-1''), 5.11(1H, m, H-2''), 1.68(H, bs, H-4'', 5''), 3.55(2H, d,  $J=7.2$ , H-1''), 5.28(1H, t,  $J=7.2$ , H-2''), 1.79(3H, bs, H-4''), 2.00(2H, m, H-5''), 2.02(2H, m, H-6''), 5.05(1H, m, H-7''), 1.62(3H, bs, H-9''), 1.55(3H, bs, H-10''), 2.33(3H, s, Me), 2.30(3H, s, Me), 2.30(3H, s, Me).  $^{13}C$  NMR ( $\delta$ ,  $CDCl_3$ ): 153.6(C-2), 116.8(C-3), 106.3(C-3a), 119.7(C-4), 118.5(C-5), 150.0(C-6), 132.4(C-7), 154.5(C-7a), 129.6(C-1'), 126.5(C-2'), 148.6(C-3'), 118.0(C-4'), 146.0(C-5'), 118.1(C-6'), 26.8(C-1''), 122.0(C-2''), 131.4(C-3''), 18.0(C-4''), 25.5(C-5''), 23.6(C-1''), 120.8(C-2''), 136.2(C-3''), 16.2(C-4''), 39.6(C-5''), 26.6(C-6''), 124.1(C-7''), 132.3(C-8''), 25.6(C-9''), 17.6(C-10''), 21.0, 20.9, 20.8(Ac, Me), 168.9, 169.0, 167.7(Ac-C=O).

**Fraction 5 and Fraction 6:** The TLC of the both fractions showed two same major spots, they were subjected on chromatography (silica gel 4 mm and 1 mm plate on chromatotron) eluting with MeOH- $CH_2Cl_2$ (1%—5%) system. Kuwanon H and mulberrofuran K were supplied. By the same way mulberrofuran G and mulberrofuran G wre isolated from fraction 7 and fraction 9 respectively.

Kuwanon H: yellow amorphous powder,  $C_{45}H_{44}O_{11}$ , ( $M^+$ 760), mp 187—189°C (decomp).  $IR_{\max}^{KBr} cm^{-1}$ : 3380, 2920, 1700, 1650, 1620, 1500, 1430, 1370, 1290, 1240, 1160, 1055, 980, 845, 810, 630, MS  $m/e$  (%): 760(24), 555(10), 421(14), 355(13), 299(8), 267(11), 239(5), 205(56), 149(100), 103(19), 85(37), 59(22),  $^1H$  NMR( $\delta$ , acetone- $D_6$ ): 6.00(1H, m, H-6), 6.66(1H, m, H-3'), 6.56(1H, dd,  $J=2.8$ , H-5'), 7.30(1H, d,  $J=8$ , H-6'), 3.12(2H, d,  $J=7$ , H-9), 5.06—5.18(1H, m, H-6), 6.66(1H, m, H-3'), 1.47 and 1.62(each 3H, s, H-11), 4.43(2H, H-14, 15), 1.57(3H, br.s, H-16), 1.80, 2.05(2H, m, H-18), 3.84(1H, m, H-19), 4.62(1H, m, H-20), 6.07(1H, d,  $J=8$ , H-26), 6.82(1H, d,  $J=8$ , H-27), 6.22(1H, m, H-30), 6.00(1H, m, H-32), 7.92(2H, brs, OH), 8.82(2H, brs, OH), 9.04, 9.42(2  $\times$  H, brs, OH), 12.85(1H, brs, 5-OH), 13.35(1H, brs, H-23-OH).  $^{13}C$  NMR ( $\delta$ , DMSO): 159.04(C-2), 119.53(C-3), 182.61(C-4), 103.61(C-4a), 156.26(C-5), 97.40(C-6), 161.54(C-7), 106.80(C-8), 160.17(C-8a), 23.42(C-9), 121.76(C-10), 131.12(C-11), 25.46(C-12), 17.38(C-13), 22.90(C-14), 123.15(C-15), 132.71(C-16), 22.43(C-17), C-18 and C-19 were overlapped in DMSO peaks. 45.45(C-20), 208.14(C-21), 113.69(C-22), 161.94(C-23), 113.35(C-24), 161.54(C-25), 106.71(C-26), 122.23(C-27), 121.76(C-28),

155.80(C-29), 102.61(C-30), 155.80(C-31), 106.57(C-32), 131.12(C-33), 111.29(C-1'), 156.30(C-2'), 102.50(C-3'), 160.79(C-4'), 106.39(C-5'), 129.51(C-6'), 21.13(C-34), 122.23(C-35), 130.26(C-36), 25.35(C-37), 17.59(C-38) [6].

**Kuwanon H Hexacetate:** kuwanon H 120 mg was reacted with  $\text{Ac}_2\text{O}$  2 mL and pyridine (1 mL) in the  $-26^\circ\text{C}$  for 2 h and evaporated in vacuo. The residue was isolated on chromatotron (1 mm silica gel plate) eluting with 0.5% isopropanol in  $\text{CH}_2\text{Cl}_2$  heptoacetate (34.6 mg) and octoacetate (14.8 mg) were given.

**Kuwanon H Octoacetate:** amorphous powder  $\text{C}_{39}\text{H}_{58}\text{O}_{18}$  ( $M^+1054.3621$ ), mp  $106-108^\circ\text{C}$ , MS  $m/e$  (%): 1054(12), 1012(18), 1012(8), 970(2), 765(18), 732(7), 629(4), 546(10), 489(10), 363(4), 289(21), 247(60), 205(100), 149(35),  $^1\text{H}$  NMR ( $\delta$ , Aceton- $\text{D}_6$ ): 8—6 no peak, 2.0—2.4(24H,  $8 \times s$ ,  $8 \times \text{AC-Me}$ ).

**Kuwanon H Heptoacetate:** Kuwanon H (274 mg) was reacted with  $\text{Ac}_2\text{O}$ -pyridine (4 mL+2 mL) in room temperature for 2h. and evaporated in vacuo. The residue was isolated on chromatotron (1 mm silica gel plate) using solvents system 0.5% isopropanol- $\text{CH}_2\text{Cl}_2$ , heptoacetate (34.6mg) and octoacetate (14.8 mg) were provide.

**Kuwanon H Octoacetate** Kuwanon H (78.8 mg) was reacted with  $\text{Ac}_2\text{O}$ -pyridine (1 mL+0.5 mL) in  $60^\circ\text{C}$  for mins. The product was dried in vacuo and isolated on chromatotron (silica gel) using solvents 0.5% isopropanol- $\text{CH}_2\text{Cl}_2$  to get octoacetate (18 mg) and together heptoacetate (10.3 mg).

**Kuwanon H octoacetate:** amorphous powder,  $\text{C}_{61}\text{H}_{60}\text{O}_{19}$ , ( $M^+1096.3726$ ), mp  $110-112^\circ\text{C}$ ,  $\text{IR}_{\text{max}}^{\text{KBr}}\text{cm}^{-1}$ : 1920, 1770, 1715, 1645, 1615, 1500, 1370, 1200, 1100, 1020, 910, 830. MS  $m/e$  (%): 1096(5), 1054(10), 1012(8), 970(2), 765(18), 723(7), 629(4), 546(10), 489(10), 363(4), 289(21), 247(60), 205(100), 149(35).  $^1\text{H}$  NMR ( $\delta$ , Acetone- $\text{D}_6$ ):  $\delta$ 8—16 no peaks, 2.0—2.4(24H,  $8 \times s$ ,  $8 \times \text{Ac-Me}$ ).

**Mulberrofuran K:** white amorphous powder,  $\text{C}_{39}\text{H}_{32}\text{O}_8$ , mp  $174-179^\circ\text{C}$  (decomp).  $\text{IR}_{\text{max}}^{\text{KBr}}\text{cm}^{-1}$ : 3450, 2970, 1620, 1600, 1510, 1435, 1365, 1260, 1120, 1050, 975, 820, 735, 630. MS  $m/e$  (%): 628 ( $M^+$ 75), 613(14), 519(9), 453(18), 387(7), 321(100), 279(8), 255(10), 203(17), 161(30), 85(38).  $^1\text{H}$  NMR ( $\delta$ , Acetone- $\text{D}_6$ ): 7.05(1H, s, H-3), 7.41(1H, d,  $J=8.4$ , H-4), 6.81(1H, dd,  $J=8.4$ , 2.2, H-5), 6.98(1H, d,  $J=2.2$ , H-7), 6.95(1H, d,  $J=1.7$ , H-2'), 6.96(1H, d,  $J=1.7$ , H-6'), 6.45(1H, m,  $J=5.4$ , H-2''), 3.37(1H, m,  $J=5.4$ , H-3''), 3.39(1H, d,  $J=5.4$ , H-4''), 2.96(1H, dt,  $J=5.4$ , H-5''), 2.73, 2.04(dd, 2H,  $J=5.4$ , 17.0, H-6''), 1.78(3H, s, H-7''), 6.27(1H, d,  $J=8.7$ , H-13''), 7.07(1H, d,  $J=8.7$ , H-14''), 6.38(1H, d,  $J=2.5$ , H-17), 6.51(1H, dd,  $J=8.4$ , 2.5, H-19''), 7.15(1H, d,  $J=8.4$ , H-20''), 6.69(1H, d,  $J=10.0$ , H-21''), 5.67(1H, d,  $J=10.0$ , H-22''), 1.34(6H, s, H-24' and 25'').  $^{13}\text{C}$  NMR ( $\delta$ , Acetone- $\text{D}_6$ ): 154.8(C-2), 102.2(C-3), 122.5(C-3a), 121.9(C-4), 113.2(C-5), 156.7(C-6), 98.3(C-7), 156.7(C-7a), 131.1(C-1'), 105.2(C-2'), 155.0(C-3'), 113.2(C-4'), 157.0(C-5'), 104.9(C-6'), 133.8(C-1''), 122.7(C-2''), 34.8(C-3''), 37.7(C-4''), 28.4(C-5''), 36.6(C-6''), 23.8(C-7''), 101.9(C-8''), 119.0(C-9''), 154.5(C-10''), 111.1(C-11''), 152.6(C-12''), 107.6(C-13''), 129.1(C-14''), 117.6(C-15''), 153.3(C-16''), 103.8(C-17''), 157.6(C-18''), 109.7(C-19''), 127.8(C-20''), 117.9(C-21''), 129.9(C-22''), 76.6(C-23''), 27.6(C-24''), 27.5(C-25'') [6].

**Kuwanon G:** yellow powder. mp  $214-220^\circ\text{C}$  (decomp).  $\text{C}_{40}\text{H}_{36}\text{O}_{11}$ ,  $\text{IR}_{\text{max}}^{\text{KBr}}\text{cm}^{-1}$ : 3400, 2980, 1720, 1640, 1540, 1480, 1390, 1260, 1180, 1010, 875, 660. MS  $m/e$  (%): 692 ( $M^+$ 20), 555(2), 421(8), 377(5), 355(7), 279(5), 203(12), 177(10), 137(100), 119(39), 85(58), 69(48) [7].

**Mulberrofuran G:** white amorphous powder, mp  $160^\circ\text{C}$  (decomp.).  $\text{C}_{34}\text{H}_{26}\text{O}_8$ ,  $\text{IR}_{\text{max}}^{\text{KBr}}\text{cm}^{-1}$ : 3400, 1690, 1625, 1600, 1510, 1445, 1370, 1260, 1150, 1045, 975, 840, 775, 630.  $^1\text{H}$  NMR (Aceton- $\text{D}_6$ ): 7.04(1H, s, H-3), 7.41(1H, d, H-4), 6.81(1H, d, H-5), 6.97(1H, s, H-7), 6.98(1H, s, H-2'), 6.94(1H, s, H-6'), 6.46(1H, s, H-2''), 3.50(1H, m, H-3''), 3.35(1H, m, H-4''), 2.99(1H, m, H-5''), 2.72, 2.04(each 1H, m,

H-6"), 1.78(3H, s, H-7"), 6.42(1H, s, H-11"), 6.23(1H, d, H-13"), 7.24(1H, d, H-14"), 6.38(1H, s, H-17"), 6.51(1H, d, H-19"), 7.14(1H, d, H-20").  $^{13}\text{C}$  NMR ( $\delta$ , Aceton- $\text{D}_6$ ): 155.0(C-2), 102.2(C-3), 122.5(C-3a), 121.9(C-4), 113.2(C-5), 156.7(C-6), 98.3(C-7), 156.7(C-7a), 131.0(C-1'), 105.1(C-2'), 154.5(C-3'), 113.4(C-4'), 157.8(C-5'), 105.4(C-6'), 133.7(C-1''), 122.8(C-2''), 35.1(C-3''), 37.2(C-4''), 28.5(C-5''), 36.2(C-6''), 23.8(C-7''), 102.6(C-3''), 116.9(C-9''), 159.8(C-10''), 104.6(C-11''), 157.4(C-12''), 107.2(C-13''), 130.3(C-14''), 117.5(C-15''), 153.3(C-16''), 103.9(C-17''), 157.7(C-18''), 109.8(C-19''), 127.8(C-20'')<sup>[8]</sup>.

**Acknowledgment** We are grateful to NCI(U.S.A.), Science and Technology Committee of Yunnan Province and Laboratory of Phytochemistry, Kunming Institute of Botany, The Chinese Academy of Sciences for their financial supports.

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